FINAL REPORT

Assessment of Geology, Energy, and Minerals (GEM) Resources

MULE SPRINGS VALLEY GEM RESOURCE AREA

(OR-010-23)

HARNEY COUNTY, OREGON

Prepared for

United States Department of the Interior
United States Bureau of Land Management
Scientific Systems Development Branch

March 1983

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MULE SPRINGS VALLEY GEM RESOURCE AREA REPORT

Errata sheets

Please sustitute these maps for the respective maps on the text:

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and Land classification map	Page IV-2

Assessment of Geology, Energy, and Minerals (GEM) Resources

Mule Springs Valley GRA
(OR - 010 - 23)
Harney County, Oregon

Prepared For:

United States Department of the Interior
United States Bureau of Land Management
Scientific Systems Development Branch

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BLM Contract No.: YA - 553 - CT2 - 1042

March, 1983

This report was prepared as part of a Phase I Assessment of GEM Resources within designated Wilderness Study Areas in Oregon, Idaho and Nevada.

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DISCLAIMER

This document is part of a report prepared under Contract Number YA - 553 - CT2 - 1042 for the United States Department of the Interior, Bureau of Land Management. Although officials of the Bureau of Land Management have provided guidance and assistance in all stages of the project, the contents and conclusions contained herein do not necessarily represent the opinions or policies of the Bureau.

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- Dr. Antonius Budding - Oil Shale and Tar Sands
- Mr. Raymond Corcoran - Field Verification
- Dr. James Firby - Paleontology
- Mr. Ralph Mason - Coal
- Mr. Richard Miller - Uranium and Thorium
- Mr. Vernon Newton - Oil and Gas
- Mr. Herbert Schlicker - Industrial Minerals and Geologic Hazards
- Dr. Walter Youngquist - Geothermal
- Dr. Paul Weis - Metals and Non - Metals.

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Mr. Tom Mitchell assisted in the stream sediment sampling program. Bondar - Clegg provided the geochemical analysis of stream sediment samples.

Ms. Pamela Ruhl provided clerical and editorial assistance throughout the project. Ms. Sara Mathews assisted with occurrence information and drafting. Mr. Philip R. Jones and Mr. Michael A. Becker produced all documents relating to the project using TERRADATA's word processing and document production systems.

EXECUTIVE SUMMARY

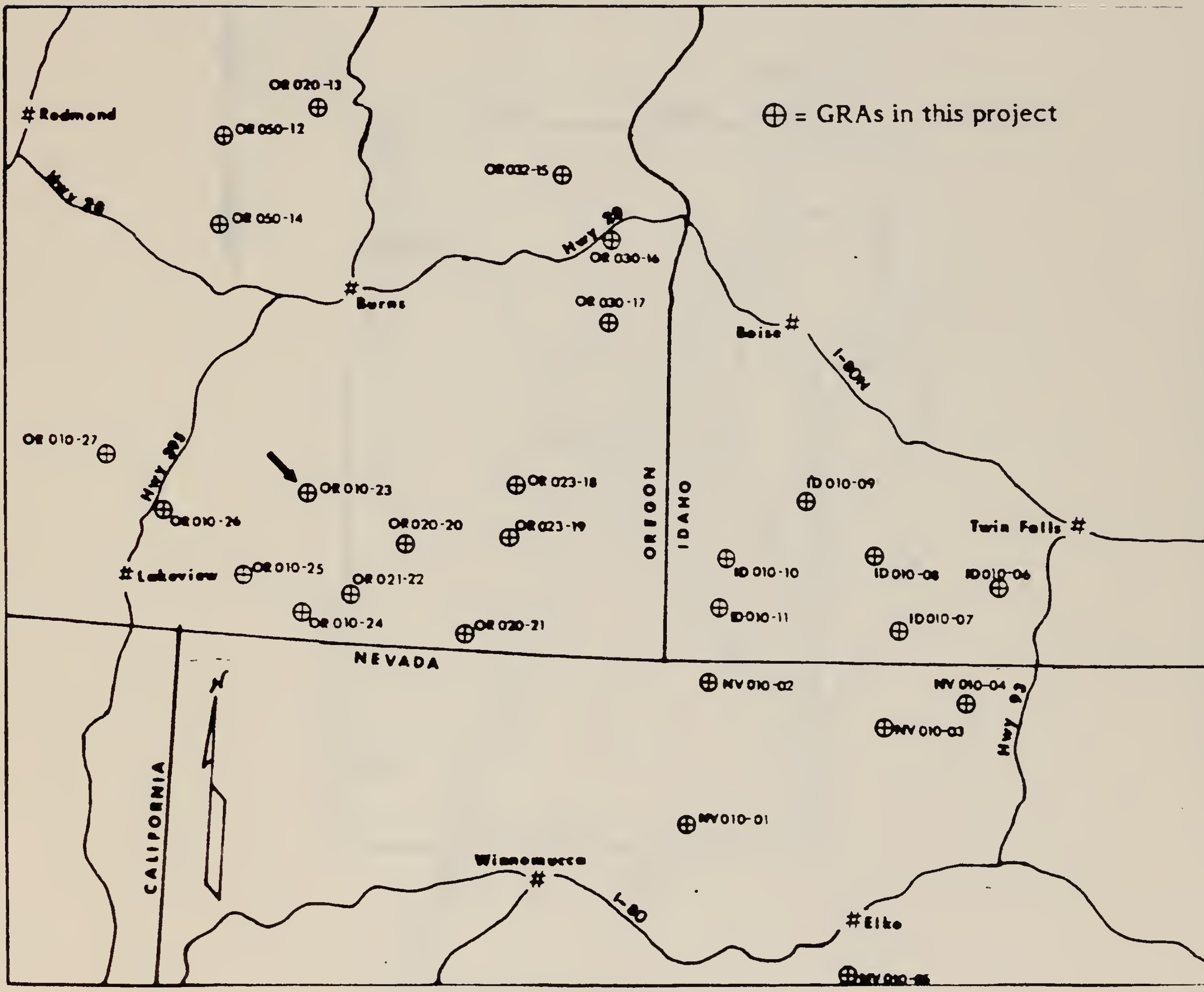
The purpose of this project is to evaluate and classify environments favorable for the occurrence of GEM resources in southeastern Oregon, southwestern Idaho, and northern Nevada. **(See the TERRADATA report entitled "Procedures for the Assessment of Geology, Energy, and Minerals (GEM) Resources.")** GEM resource environments have been rated on a scale that ranges from one to four, with one being least favorable and four being most favorable. Favorability classes two and three represent low and moderate favorability, respectively. Confidence levels range from A to D with A being low confidence and D being high confidence. The confidence levels are directly related to the quantity and quality of the information available for the determination of the favorability classes.

The specific area with which this report deals is the Mule Springs Valley GEM resource area (GRA OR-010-23) which is located in south-central Oregon (see attached location map). The GRA contains about 216 square miles within Townships 30S through 32S and Ranges 27E through 28E. It contains one WSA; WSA 1-78 which comprises 22,800 acres. The study area is in the Warner Lakes Resource Area of the Lakeview BLM District. It is about 65 miles from Burns, Oregon.

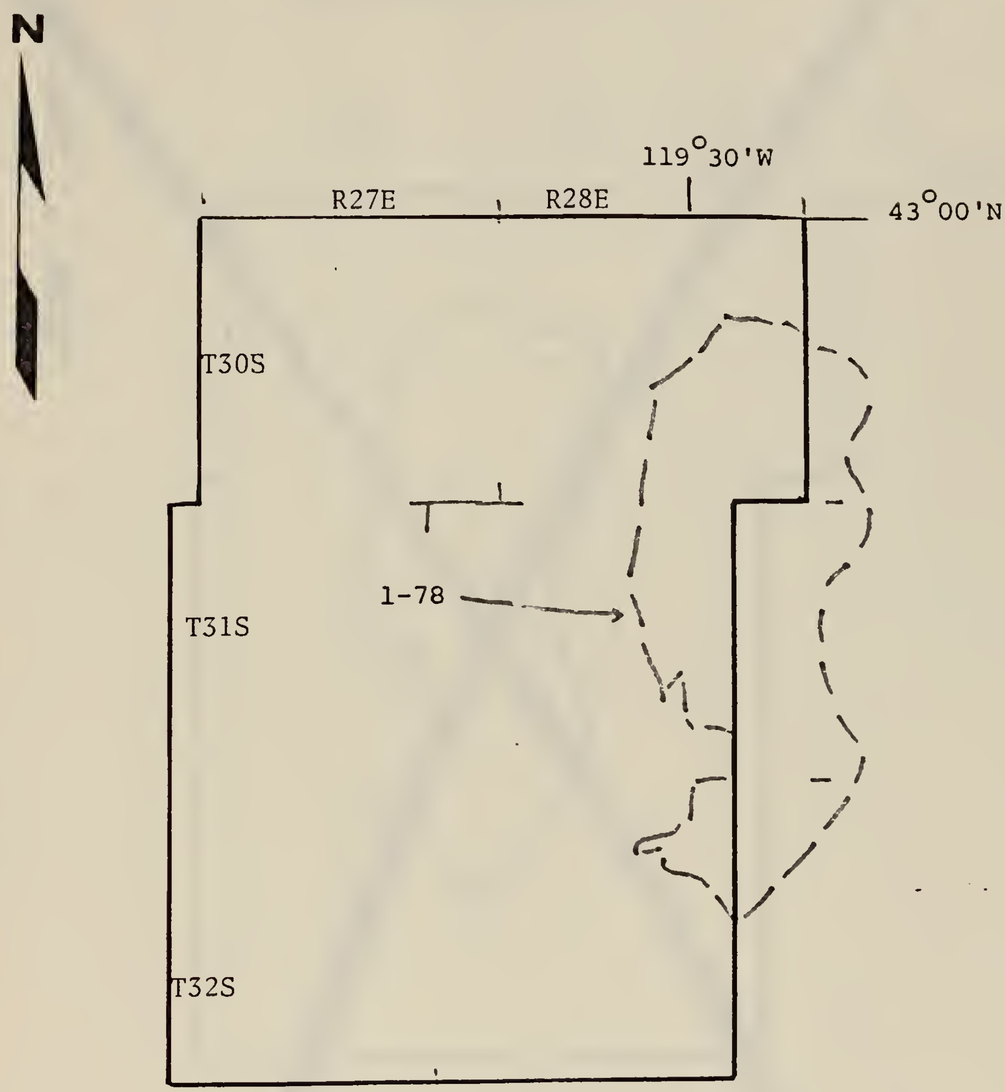
The GRA is within the Great Basin sub-province of the Basin and Range physiographic province. It is underlain by rocks that range from Paleozoic miogeoclinal sediments to Tertiary volcanics and volcaniclastic strata. The area is west of the major structural Antler orogenic belt. Basin and Range fault blocks are common in this portion of Oregon.

The Mule Springs Valley GRA contains several geologic environments that are variously favorable for GEM resources. The GRA is moderately favorable (Class 3C) for the occurrence of zeolite (clinoptilolite) resources. This classification signifies that the geologic environment, the inferred geologic processes and the reported mineral occurrences indicate moderate favorability for the accumulation of clinoptilolite, and that the available data provide direct evidence but are quantitatively minimal to support the possible existence of mineral resources. The study area may contain an environment similar to that found south of the GRA in which zeolite deposits occur.

GRA Location Map



Land Classification Map
Mule Springs Valley GRA
(OR - 010 - 23)
Harney County, Oregon



Scale 1:250,000
(Adel 1°x2° NTMS Quadrangle)

Classification Of Lands Within The
Mule Springs Valley GRA
(OR - 010 - 23)
Harney County, Oregon
For GEM Resource Potential

COMMODITY	AREA	CLASSIFICATION LEVEL	CONFIDENCE LEVEL	REMARKS
Metals	Entire GRA	1	B	
Geothermal	Entire GRA	1	C	
Uranium/Thorium	Entire GRA	1	A	
Coal	Entire GRA	2	B	
Oil and Gas	Entire GRA	2	A	
Tar Sands/Oil Shale	Entire GRA	1	C	
Limestone	Entire GRA	1	A	
Bentonite	Entire GRA	1	A	
Diatomite	Entire GRA	2	C	
Clinoptilolite	Entire GRA	3	C	
Paleontology	Entire GRA	1	C	
Hazards	See Hazards Map (GRA File)			
ESLs	None	1	C	

LEGEND:
Class 1 - Least Favorable
Class 2 - Low Favorability
Class 3 - Moderate Favorability
Class 4 - High Favorability

Confidence Level A - Insufficient data or no direct evidence
Confidence Level B - Indirect evidence available
Confidence Level C - Direct evidence but quantitatively minimal
Confidence Level D - Abundant direct and indirect evidence

The entire GRA is favorable to varying degrees for coal, oil and gas, and diatomite resources (see attached map).

TERRADATA recommends that further surface geologic investigations be undertaken in the Mule Springs Valley GRA in order to increase confidence levels in the classifications. Detailed geologic mapping and geochemical investigations would be useful in upgrading the land classification of this area. Selective drilling of geochemical and/or geophysical anomalous areas would contribute to the refinement of the confidence level and favorability rating in this GRA.

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1. INTRODUCTION

This report is one of 27 GRA technical reports that summarize the results of a Phase 1 assessment of the geology, energy, and minerals (GEM) resources in selected portions of southeastern Oregon, southwestern Idaho, and northern Nevada. The study region was subdivided into 27 GEM resource areas (GRAs), principally for ease of data management and interpretation. The assessment of GEM resources for this project consisted of an interpretation of existing literature and information by experts knowledgeable in both the geographic area and specific commodities. It is possible that the assessment would be different if detailed field exploration, geochemical sampling, and exploratory drilling programs were undertaken. (See the TERRADATA report entitled "Procedures for the Assessment of Geology, Energy, and Minerals (GEM) Resources.")

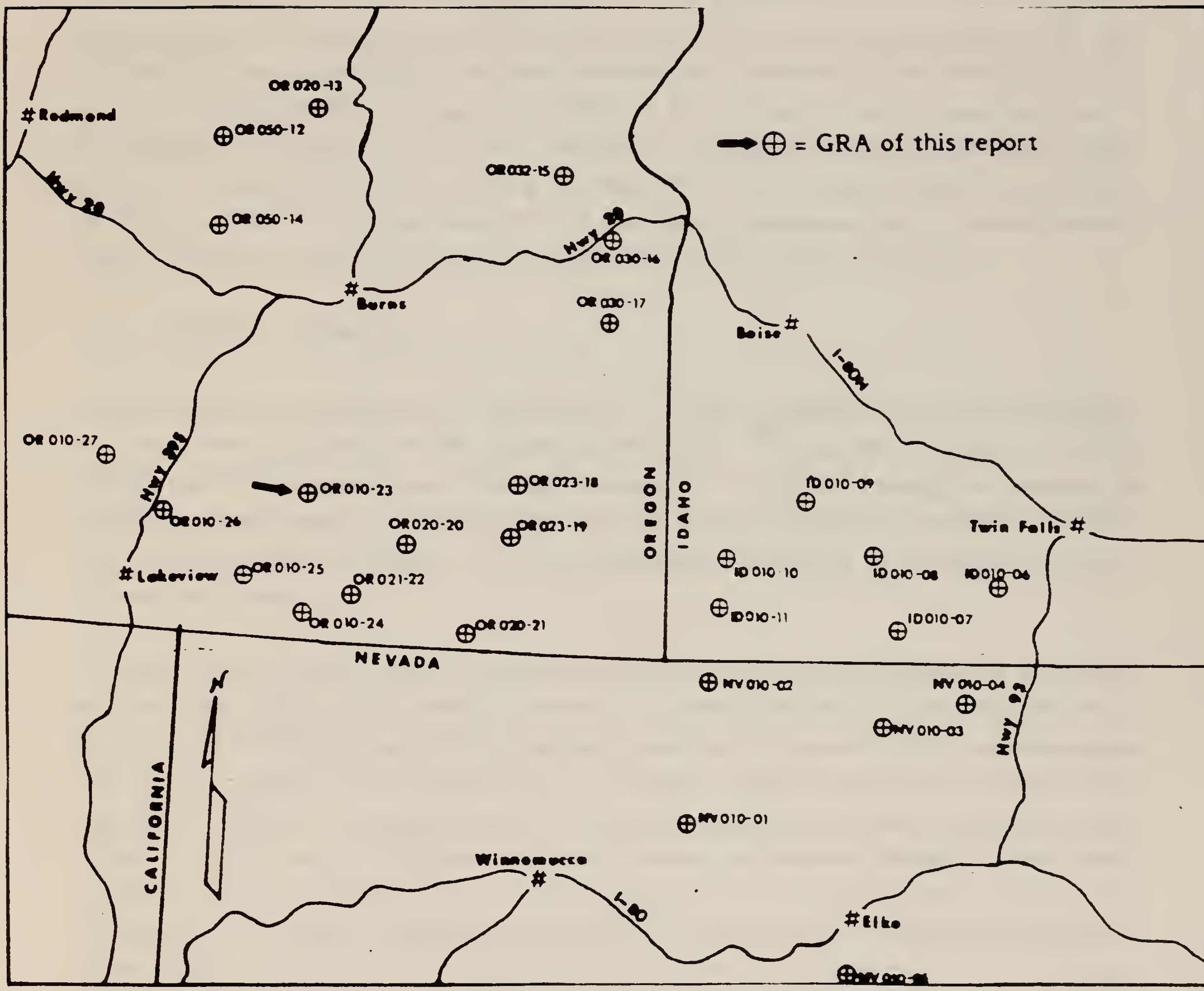
This report summarizes the assessment of the GEM resources potential of the Mule Springs Valley GRA (OR-010-23). See Figure 1-1. Commodity categories for which this GRA was evaluated are:

- Metals
- Oil and Gas
- Oil Shale and Tar Sands
- Geothermal
- Uranium and Thorium
- Coal
- Industrial Minerals
- Paleontological Resources
- Geologic Hazards
- Educational and Scientific Localities (ESLs)

Geologic environments within the Mule Springs Valley GRA have been rated with respect to their favorability for the occurrence of these different commodities. The favorability rating scale ranges from one to four, with one being least favorable and four being most favorable. Confidence levels in these ratings also have been assigned. These confidence levels range from A to D, with A being low confidence and D high confidence. Assigned confidence levels are related to the quantity and quality of the information available for the determination of the favorability ratings.

FIGURE 1-1

GRA Location Map



2. DESCRIPTION OF THE MULE SPRINGS VALLEY GRA

2.1 LOCATION

The Mule Springs Valley GRA (OR-010-23) is in south-central Oregon. It lies between latitudes 42°45'N and 43°00'N and longitudes 119°28'W and 119°43'W. The GRA contains approximately 216 square miles within Townships 30S through 32S and Ranges 27E and 28E (see Figures 1-1 and 2-1). The area contains one Wilderness Study Area; WSA 1-78 (22,800 acres). The Mule Springs Valley GRA is in the Warner Lakes Resource Area of the Lakeview BLM District. The area is about 65 miles from Burns, Oregon which is the nearest transportation center offering a minimum of rail, highway, and/or charter-air services. Access to the contained WSA is via county maintained dirt or packed-gravel roads. Vehicular access to the interior of the WSA is poor to non-existent.

2.2 GENERAL GEOLOGY

The Mule Springs Valley GRA is in the Adel 1°x2° NTMS Quadrangle. The data available for this area includes NURE investigations[1, 2, 3]*, general mineral resource information[4], and small scale geologic mapping[5]. Detailed geologic information is lacking in most areas. No information for this GRA is available from MILS or CRIB. There are no claims or leases. The overall quantity and quality of commodity specific information is poor.

The Mule Springs Valley GRA is within the northern section of the Great Basin portion of the Basin and Range physiographic province. The Basin and Range Province consists of generally north-trending fault-block mountains separated by parallel intermontane basins. The mountain blocks are commonly ten to twelve miles wide and are separated by alluviated valleys of comparable width. Elevation ranges from below sea-level at Death Valley to more than 13,000 feet at White Mountains Boundary Peaks. Local relief generally is less that 5,000 feet. The physiography of the Great Basin reflects the structural and lithologic complexity of the underlying bedrock. The Great Basin portion of the Basin and Range Province extends from southern Nevada northward into southern Oregon. The northern-most extremity is located just north of the town of Burns, Oregon.

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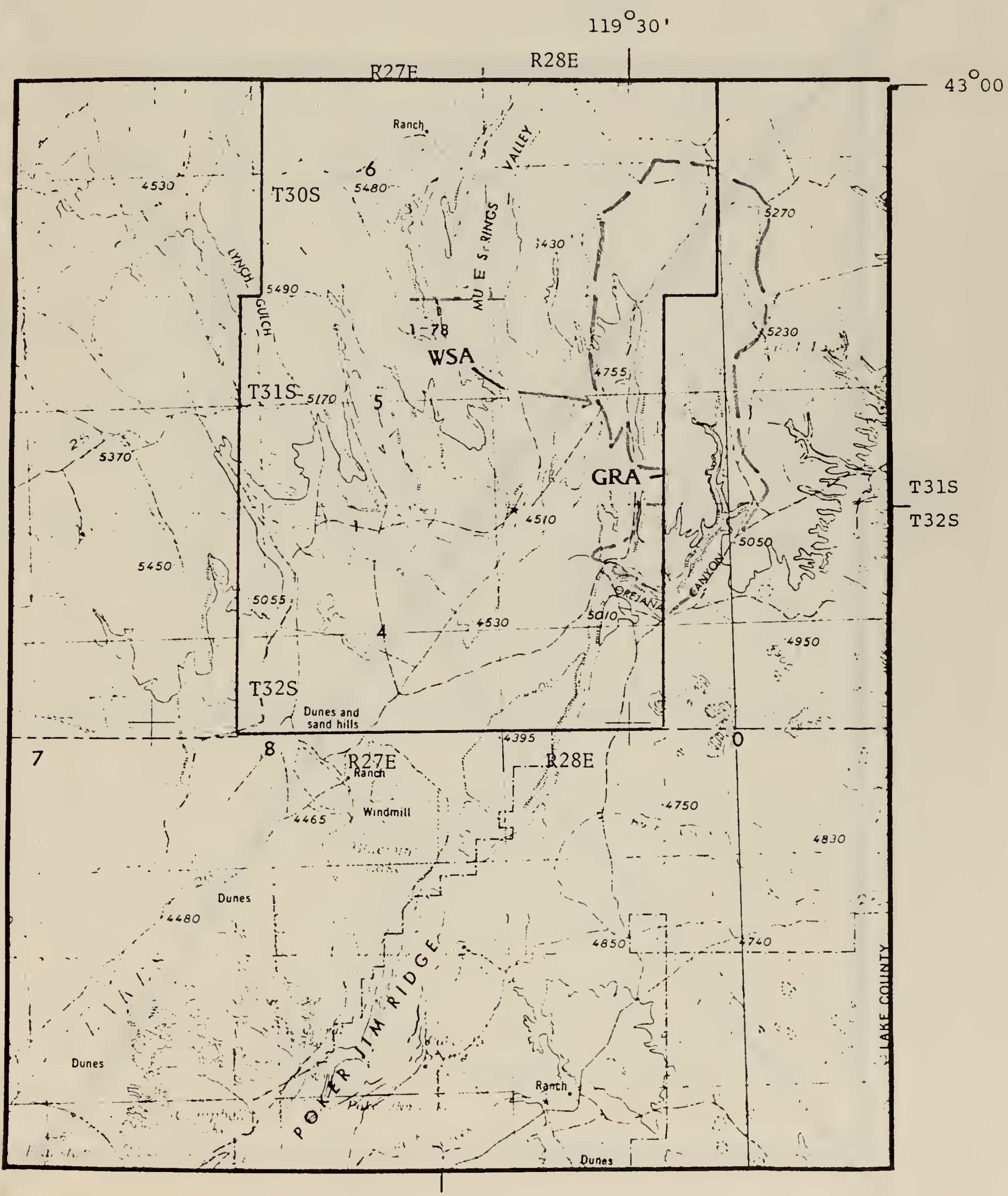
* In this report, citations are superscripted numbers. They refer to bibliographic entries listed in Appendix A, References Cited.

FIGURE 2-1

Topographic Map
Mule Springs Valley GRA
(OR-010-23)
Harney County, Oregon



Scale 1:250,000
(Adel 1°x2° NTMS Quadrangle)

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The part of the Basin and Range Province that lies in southern Oregon extends eastward from the Cascade Range to the eastern limits of the Trout Creek Mountains. This part of the province is underlain predominantly by Cenozoic volcanic strata. Pre-Tertiary rocks are exposed in only two places in the Oregon part of the Basin and Range Province; in the Pueblo Mountains and in the Trout Creek Mountains of southeastern Harney County. Very little is known about the Pre-Tertiary basement elsewhere in the province. A sparce amount of data is available regarding the depth to the Pre-Tertiary basement rocks and the thickness and nature of the Tertiary cover rocks.

2.2.1 Geomorphology

The Mule Springs Valley GRA is located in the northern end of the Warner Lakes graben. The Warner Lakes graben is one of seven prominent sub-parallel grabens in the Oregon part of the Basin and Range Province. Other major grabens that occur in this part of Oregon include Crump Lake Valley, Catlow Valley, Guano Valley, and Pueblo Valley. The study area is contained almost entirely within the Warner Lakes Graben. North-trending escarpments (fault scarps), especially prominent in the southern part of the GRA, define the approximate limits of the graben. Upland surfaces represent only five percent to ten percent of the area within the GRA.

The northern one-half of the area is characterized by playas and playa-related landforms. The area is essentially flat; it contains dunes and sand hills, playa lake strandlines, and ephemeral lakes.

A low drainage divide crosses the northwest corner of the GRA. Northwest of this divide streams drain northward through Juniper Creek. Southeast of the divide the drainage is internal to the Warner Lakes basin. Streams on either side of the divide are sub-parallel, consequent streams and appear to be fault controlled.

Total relief is the GRA is about 1,100 feet. The highest point, in excess of 5,500 feet, occurs in the west-central part of the area. The lowest point, 4,400 feet, is in the southern part of the GRA. The area of greatest local relief (600 feet) is along Poker Jim Ridge in the southeastern part of the GRA.

2.2.2 Lithology and Stratigraphy

Paleozoic and Mesozoic units may occur at undetermined depths in the Mule Springs Valley GRA since this area is within the margins of both the western Triassic and the western Late Paleozoic depositional basins[6]. None of these units, however, are exposed in or near the GRA. Tertiary basalt flows are the oldest rocks exposed in the Mule Springs Valley GRA (Figure 2-2).

The majority of rocks in this GRA are Tertiary volcanogenic strata. These rocks comprise three major groups that are distinguished on the basis of chemistry and age. Eocene (?) to Early Miocene basaltic to rhyolitic rocks immediately underlie broad areas throughout the GRA. These rocks are part of widespread calc-alkalic volcanism related to subduction along the Pacific margin.

The second group of Tertiary volcanic rocks are Mid-Miocene dacitic to rhyolitic flows and ash-flow tuffs; these occur throughout the GRA. Some of these rocks are peralkaline or have peralkaline affinities. They are related to the beginning of taphrogenic activity in the area. Volcaniclastic rocks are associated with this second group of Tertiary volcanics and consist mainly of tuffaceous fluvio-lacustrine shales, mudstones, sandstones, and conglomerates. Air-fall tuff and diatomaceous sedimentary rocks also occur.

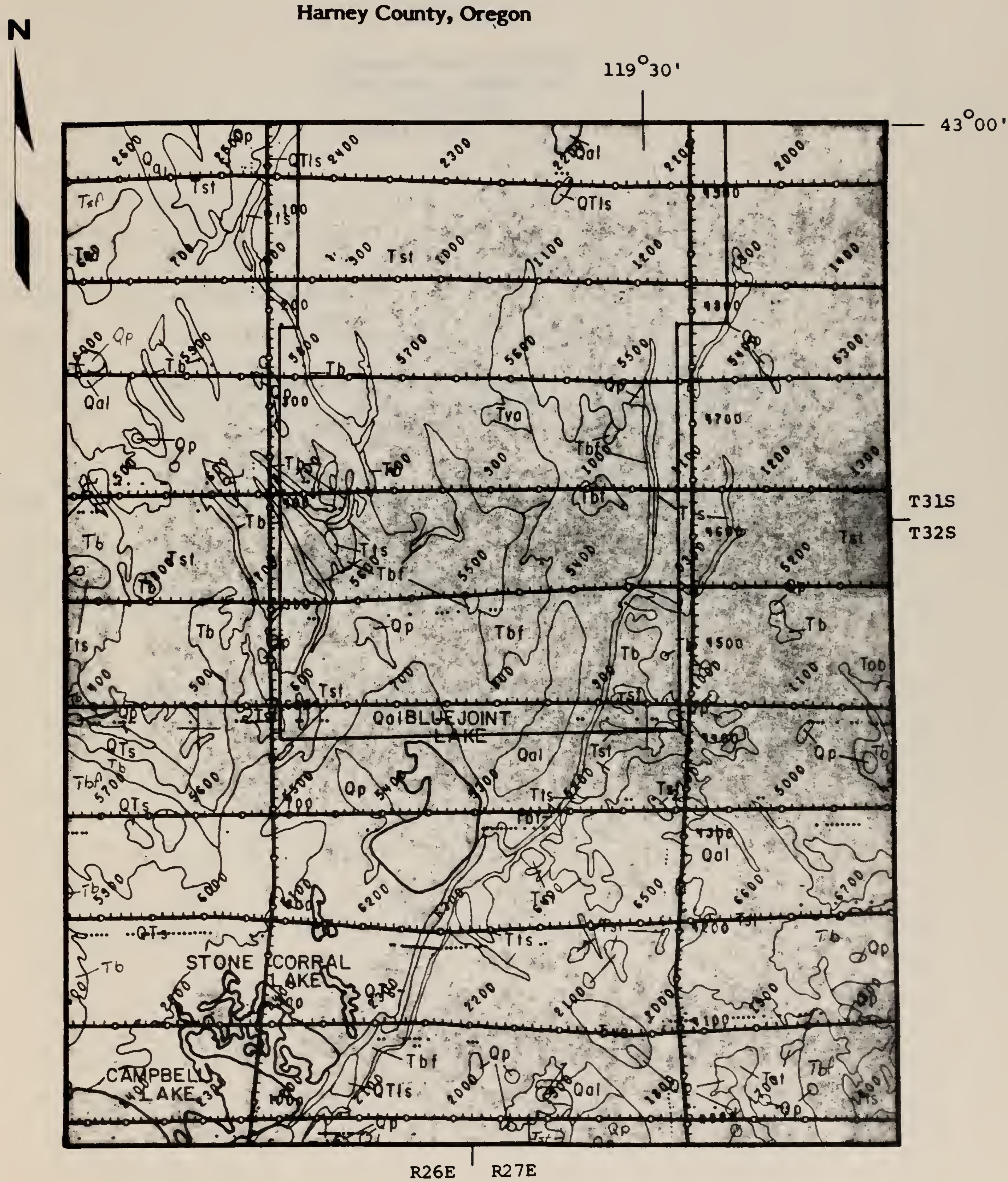
The third-group of volcanic rocks consists mostly of Middle to Late Miocene olivine basalt flows. These rocks are probably correlative with the flood basalts of the Columbia River Plateau Province. Relatively young basalt flows and other volcanic ejecta occur in the northern part of the GRA.

2.2.3 Structural Geology

The tri-state area of northeastern Nevada, southern Oregon, and southwestern Idaho is characterized by several major structural elements. During the Early Paleozoic this area was the site of marine sedimentation in the north-northeast trending Cordilleran geosyncline. Sedimentation persisted in three sub-parallel belts until the end of the Devonian Period. One sedimentation belt was located in the eastern half of Nevada and received nearshore to littoral deposits of shallow-water carbonates with a minor amount of interbedded shale and sandstone. The second sedimentation belt was in the western half of the state and was the locus of transitional, progressively deeper water deposits. The third belt, located further west, was the site of eugeoclinal deposits.

FIGURE 2-2

Geologic Map
Mule Springs Valley GRA
(OR-010-23)
Harney County, Oregon



Scale 1:250,000
(Adel 1°x2° NTMS Quadrangle)

FIGURE 2-2
(Continued)

Geologic Map Legend For
Mule Springs Valley GRA
(OR-010-23)
Harney County, Oregon

Qp	-	Playa Deposits
Qal	-	Alluvium
QTls	-	Landslide Deposits
QTs	-	Lacustrine, Fluviatile, and Acolian Sedimentary Rocks
Tst	-	Semiconsolidated Lacustrine Tuffaceous Sandstone and Siltstone, Ash and Ashy Diatomite, Conglomerate and Minor Fanglomerate, Boulder-Bearing Slope Wash, Vitric-Crystal and Vitric-Lithic Tuff, Pumice Lapilli Tuff, and Tuff Breccia.
Tob	-	Thin, Vesicular, Subophytic to Intergranular, Diktytaxitic Basalt Flows
Tb	-	Basalt
Tbf	-	Massive Basalt Flows and Minor Interbeds of Tuff and Scoria
	-	Geologic contact (dashed where inferred).

In Late Devonian time, the Antler Orogeny developed along a north-northeast trending swath through northwest Elko County, Nevada, and on into southwestern Idaho. The Mule Springs Valley GRA lies west of the axis of the Antler orogenic belt. As a direct result of the Antler orogenic uplift, a Pennsylvanian clastic wedge developed along the margins of the uplift. The orogeny culminated in a period of extensive thrust faulting that includes the Roberts' Mountain thrust.

The Sonoma Orogeny occurred in the Permian in north-central Nevada[6]. This deformational episode included more thrust faulting in the vicinity of the Mule Springs Valley GRA.

Another structural episode in this area was Basin and Range block faulting in response to tensional forces.

2.2.4 Paleontology

Late Tertiary and Early Quaternary sedimentary rocks within the GRA contain several varieties of flora and fauna. Tuffaceous lacustrine sediments contain Late Miocene (Barstovian age) mammalian vertebrate fauna in fine-grained sandstone and siltstone facies[7]. These mammalian fossil assemblages occur in Section 23 of Township 32S and Range 27E. Tertiary diatomites contain occasional fish and leaf fossils common to lacustrine environments. All other exposed volcanic lithologies are essentially devoid of fossils. Older fossil-bearing Paleozoic and Mesozoic marine and terrigenous units are not exposed in the Mule Springs Valley GRA.

2.2.5 Historical Geology

The present geologic character of the Great Basin resulted from the progressive development of the western portion of the North American continent throughout geologic time. Beginning in the Late Precambrian and continuing into the Middle Paleozoic, eastern Nevada, western Utah, southwesternmost Idaho were characterized by a miogeoclinal environment in which shelf margin carbonates, shales, and sandstones were deposited. In contrast, western Nevada and southern Oregon were in a eugeoclinal environment in which dark shales, radiolarian cherts and basaltic materials (Steinman's Trinity) were formed.

The Middle Paleozoic (Late Devonian-Early Mississippian) Antler Orogeny deformed and thrust the eugeoclinal sediments over the shelf-type sediments to the east, resulting in a north-trending highland in Central Nevada. A vast amount of fine-grained detritus was shed eastward during the Mississippian, producing thick upper Paleozoic shales in eastern Nevada and western Utah. Erosion of the Antler Highlands resulted in the deposition of coarse sediments during the Early Pennsylvanian. Thousands of feet of sandstone and conglomerate were deposited in northern Nevada around the margins of the Antler Highlands. Late Pennsylvanian and Permian shallow water sediments overlapped and overstepped the roots of the eroded highlands. Sediments deposited over the eroded Antler Highlands in the Permian were predominantly of the deep-water variety. The next significant tectonic episode (the Sonoma Orogeny) thrust the ocean floor siliceous and volcanic materials eastward over the shallow water, clastic sedimentary rocks that covered the ancient Antler Highland.

Development of western North American in the Mesozoic was dominated by oceanic plate subduction along the continental margin that resulted in a complex history of concomittant sedimentation, deformation, and igneous activity. During this time, the well-defined overthrust belt that extends from Canada to Mexico was formed. This deformation occurred during the Sevier (Late Jurassic to Latest Cretaceous) and Laramide orogenies (Latest Cretaceous to Early Tertiary Eocene).

Widespread silicic volcanic rocks formed in the Great Basin in Early and Middle Cenozoic time (primarily 20-34 million years ago). During Late Cenozoic time volcanic activity of the Great Basin changed to a bimodal basalt-rhyolite assemblage that reflects the taphrogenic character of the region. It was also during this time that the tectonic character of the region changed from one of compression to one of extension and led to the development of the Basin and Range structure.

2.3 ENVIRONMENTS FAVORABLE FOR GEM RESOURCES

The Mule Springs Valley GRA contains one environment that is moderately favorable for the occurrence of clinoptilolite. It contains environments that have low favorability for coal, oil and gas, and diatomite GEM resources.

FIGURE 2-3

Paleogeographic Map(6)
Oregon-Idaho-Nevada
Tri-State Area

2.3.1 Environments for Metals Resources

There are no environments favorable for the accumulation of metallic resources in the Mule Springs Valley GRA. The requisite geologic criteria and evidence of inferred geologic processes are not present in the area. There are no known occurrences of metallic minerals in this GRA.[8].

2.3.2 Environments for Oil and Gas Resources

The Mule Springs Valley GRA has a low favorability for potential oil and gas resources. Potentially favorable sub-surface environments include western Triassic-and western Late Paleozoic formations, and Miocene Lake Bruneau units[6]. Prospective environments are overlain by Tertiary volcanics; therefore, all of the evidence is indirect. If the environments favorable for the accumulation of oil and gas do exist, then the associated Basin and Range faults might provide structural traps.

2.3.3 Environments for Oil Shale and Tar Sands Resources

The Mule Springs Valley GRA contains no environments favorable for the occurrence of oil shale or oil impregnated sand[9]. The area is underlain predominantly by Tertiary volcanics. Potential sedimentary hosts are largely tuffaceous and contain only minor amounts of non-volcanic clastic material and carbonates. Favorable lithologies are not present.

2.3.4 Environments for Geothermal Resources

The Mule Springs Valley GRA has a low favorability for geothermal resources. Structural criteria are met by Basin and Range faults associated with the Warner Lakes graben. Young volcanics occur within the GRA. However, there is no direct evidence in the form of known geothermal occurrences[10].

2.3.5 Environments for Uranium and Thorium Resources

There are no environments favorable for the occurrence of uranium or thorium resources in the Mule Springs Valley GRA[11]. Favorable source rocks, potential reductants, and evidence of inferred processes of mineralization are all lacking in this study area.

2.3.6 Environments for Coal Resources

The Mule Springs Valley GRA contains low favorability for the occurrence of coal and lignite deposits[12]. The chances for coal or carbonaceous materials to have formed in the study area are remote. The geology of the Mule Springs Valley GRA region does not support environments favorable for the formation of coal deposits. The area is underlain or is mantled with accumulations of highly tuffaceous sediments and related volcanic products. There is no evidence to support the inference that a coal-forming environment existed within this GRA.

2.3.7 Environments for Industrial Minerals Resources

The Mule Springs Valley GRA contains environments favorable for the accumulation of clinoptilolite GEM resources. Environments favorable for zeolites (clinoptilolite) occur south of the GRA near Hart Mountain. Similar deposits may be inferred to be present in playa sediments within the study area[13].

2.3.8 Environments for Paleontological Resources

The Mule Springs Valley GRA contains one environment that is highly favorable for paleontological resources. Tuffaceous lacustrine sediments in the eastern part of this area (Figure 2-2, map unit Tst) contain Miocene vertebrate fossil localities and occasional leaf and fish fossils. Most of the other lithologies within the GRA have low favorability for these resources[7].

2.3.9 Environments for Geologic Hazards

Potential geologic hazards in the Mule Springs Valley GRA consist of mapped and interpreted faults, landslides, and volcanic centers[13]. These features were noted from aerial photographs, geologic maps, and topographic maps. There is no historical record of violent seismic or volcanic activity the area. The potential for mass movement exists along all the over-steepened slopes within the GRA.

2.3.10 Educational and Scientific Localities

There are no known ESLs in the Mule Springs Valley GRA.

3. ENERGY AND MINERAL RESOURCES IN THE MULE SPRINGS VALLEY GRA

The Mule Springs Valley GRA has an overall low favorability for the occurrence of GEM resources.

3.1 KNOWN DEPOSITS

The Mule Springs Valley GRA contains no known deposits.

3.2 OCCURRENCES

The Mule Springs Valley GRA contains no CRIB, MILS, or NURE-related localities.

3.3 CLAIMS

The Mule Springs Valley GRA contains no known claims as of 15 August, 1982

3.4 LEASES

The Mule Springs Valley GRA is not leased or under lease application for any GEM resources, as of 15 August 1982.

3.5 DEPOSIT TYPES

There are no known deposits in the Mule Springs Valley GRA. However, stratiform, zoned zeolite deposits analogous to those found at Lake Tecopa, California, may occur within the volcanic sequences in the study area.

3.6 MINERAL ECONOMICS

The Mule Springs Valley GRA is moderately favorable for the occurrence of zeolite (clinoptilolite) resources.

3.6.1 Zeolite

The uses and potential uses of zeolites include antibiotic and pesticide carriers, heat-storage systems, methane recovery systems, detergents, catalysts, hydrogen storage, and molecular sieves. The production of natural zeolite in the United States was estimated to have doubled in 1981, from 5,000 tons in 1980. About 4,000 tons were produced at Adrian, Oregon. The 1981 price of natural zeolites ranged from $300.00 per ton to $400.00 per ton, whereas the price of synthetic zeolites ranged from $500.00 per ton to $6,000.00 per ton. Supply and demand statistics are not readily available for this commodity. Production figures also are not well known. One 1981 estimate predicts that the natural zeolite market will exceed one billion dollars in the early 1990's[14, 15].

3.7 STRATEGIC AND CRITICAL MINERALS AND METALS

The Mule Springs Valley GRA is not considered favorable for any strategic minerals or metals. (See Table 3-4 in TERRADATA's report entitled "Procedures for the Assessment of Geology, Energy, and Minerals (GEM) Resources.")

4. CLASSIFICATION OF LAND FOR GEM RESOURCES POTENTIAL

The precise location of specific favorable environments within a given GRA depends upon three principal factors:

- The precision and specificity of avaliable data;
- The nature (size and spatial distribution) of anticipated deposits as predicted from known models; and
- The geometry of the favorable geologic environments.

Commodity-specific information in the Mule Springs Valley GRA is limited. Subsurface information is virtually non-existent. Therefore, the entire area, rather than specific subareas, has been classified for individual GEM resources (Figure 4-1 and Table 4-1).

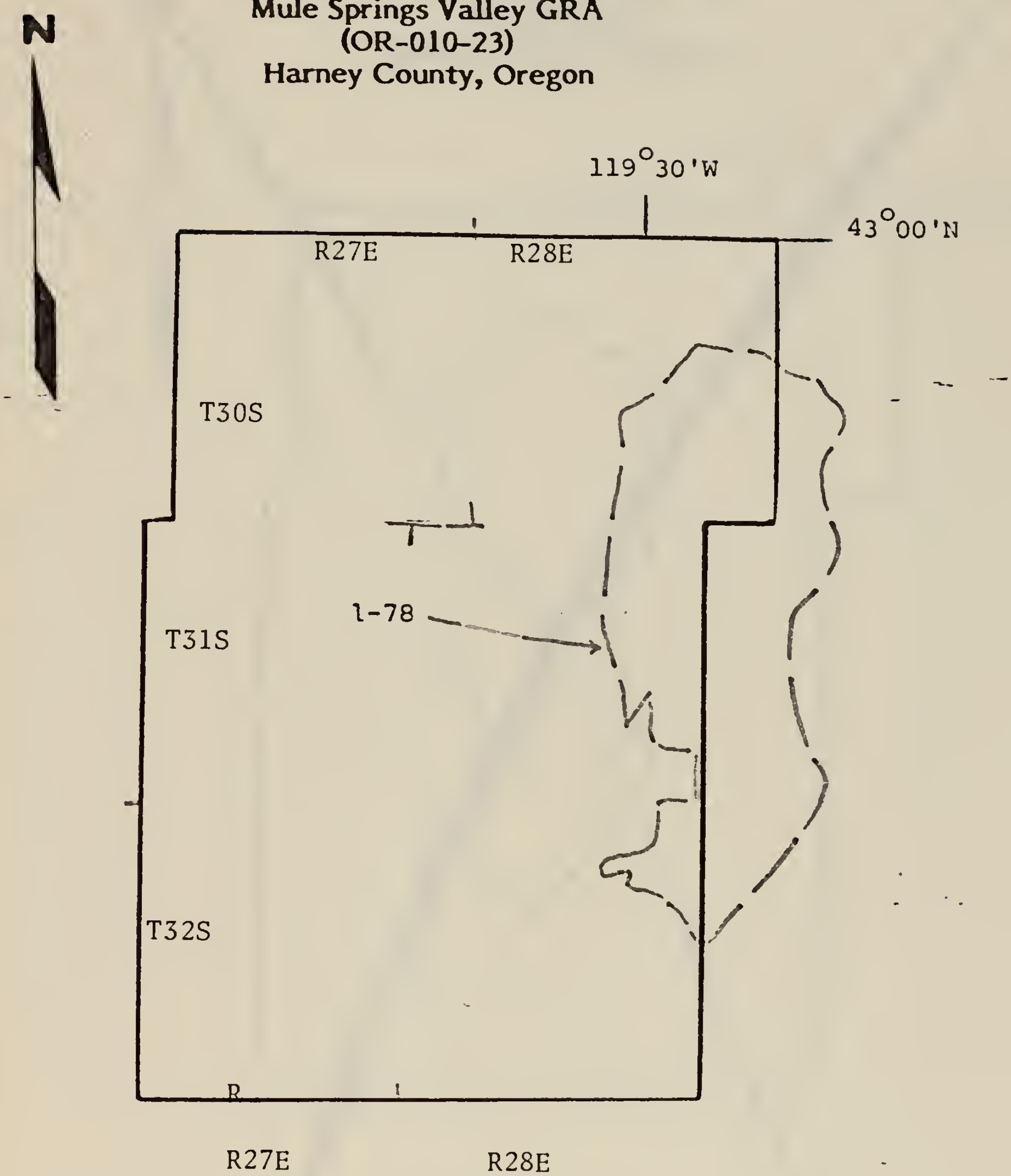
The entire Mule Springs Valley GRA is moderately favorable (Class 3C) for clinoptilolite resources. The geologic environment for this resource is common in the Tertiary volcanic sequences that occur in the study area. The C confidence level of this evaluation indicates the availability of minimal direct evidence.

The entire GRA has a low favorability (Class 2) for several GEM resources. These are coal, oil and gas, and potential diatomite resources. A Class 2 favorability indicates that the geologic environment and inferred geologic processes demonstrate a low favorability for the accumulation of these commodities. The confidence levels for these commodities range from A to B, dependent on the availability of supportive indirect evidence.

The classification (2B) of the area as having a low favorability for the accumulation of oil and gas resources agrees with the USGS classification of the same area(16). TERRADATA's classification of the area for other leasables also is in agreement with the USGS evaluation, with the exception of potential sodium deposits in the Mule Springs Valley playa(17, 18). The playa was not evaluated by TERRADATA's panelists for sodium because subsurface information is virtually non-existent in this area. The Mule Springs Valley GRA does not exhibit favorable characteristics (Class 1) for other commodities listed in Table 4-1.

FIGURE 4-1

Land Classification Map
Mule Springs Valley GRA
(OR-010-23)
Harney County, Oregon



Scale 1:250,000
(Adel 1°x2° NTMS Quadrangle)

This map is an overlay for Figures 2-1 and 2-2.

TABLE 4-1

Classification Of Lands Within The Mule Springs Valley GRA (OR - 010 - 23) Harney County, Oregon For GEM Resource Potential

COMMODITY	AREA	CLASSIFICATION LEVEL	CONFIDENCE LEVEL	REMARKS
Metals	Entire GRA	1	B	
Geothermal	Entire GRA	1	C	
Uranium/Thorium	Entire GRA	1	A	
Coal	Entire GRA	2	B	
Oil and Gas	Entire GRA	2	A	
Tar Sands/Oil Shale	Entire GRA	1	C	
Limestone	Entire GRA	1	A	
Bentonite	Entire GRA	1	A	
Diatomite	Entire GRA	2	C	
Clinoptilolite	Entire GRA	3	C	
Paleontology	Entire GRA	1	C	
Hazards	See Hazards Map (GRA File)			
ESLs	None	1	C	

LEGEND:
Class 1 - Least Favorable
Class 2 - Low Favorability
Class 3 - Moderate Favorability
Class 4 - High Favorability

Confidence Level A - Insufficient data or no direct evidence
Confidence Level B - Indirect evidence available
Confidence Level C - Direct evidence but quantitatively minimal
Confidence Level D - Abundant direct and indirect evidence

5. RECOMMENDATIONS FOR FUTURE WORK

Further work in the Mule Springs Valley GRA should be designed to increase the confidence levels of the classifications. Detailed surface investigations should be undertaken for recognition criteria for industrial minerals (e.g., weathering phenomena that might produce bentonite, clinoptilolite; ash flow tuffs with possible basal vitrophyres for perlite, etc.); for metallic deposits, such as soil chemistry, stream sediment analyses, etc. With the exception of either geophysical investigations or drilling, future work should be confined to detailed mapping, geochemical sampling, and general field exploration.

- APPENDIX A -

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